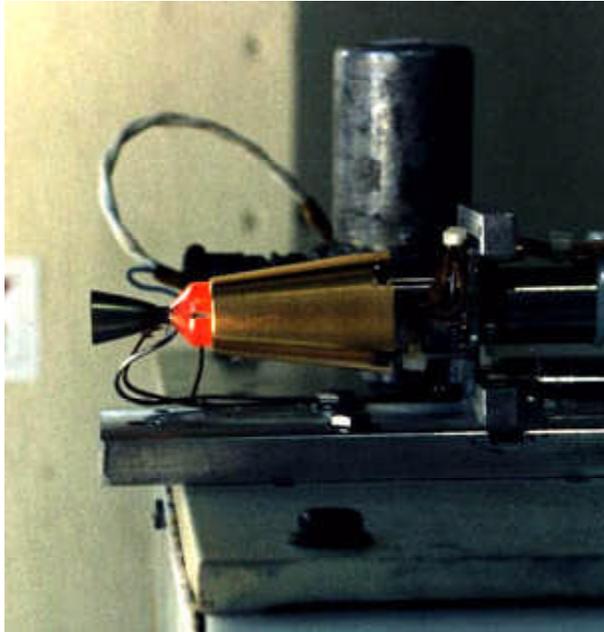


Advanced Monopropellant Thruster Technology Tested

A new family of environmentally friendly, low-freezing-point, high-density monopropellants is being developed under a NASA Glenn technology program. New monopropellant technology would greatly benefit a range of small (<100 kg) satellites and spacecraft missions. These monopropellants are mixtures of hydroxylammonium nitrate (HAN), fuel, and water. Primex Aerospace Company, under contract to the NASA Glenn Research Center at Lewis Field, tested a 1-lbf thruster using a HAN-based monopropellant formulation. Over 8000 sec of total test time was accumulated on a single thruster using the blowdown duty cycle typical of state-of-the-art monopropellant systems.

HAN-based monopropellants contain HAN as the oxidizer component (typically 60 wt %), a fuel component, and water. These monopropellants represent a range of formulations, with a corresponding range of characteristics and performance levels. Because they do not pose a shock or vapor hazard, their handling procedures are much simpler than those for hydrazine (N_2H_4). HAN-based formulations generally have lower freezing points than N_2H_4 , some as low as $-35\text{ }^\circ\text{C}$, greatly reducing the thermal management requirements for power-limited spacecraft. Although the specific impulse performance of the first-generation formulations is lower than that of hydrazine (190 versus 220 sec), these formulations are also 40-percent denser. This results in a density-specific impulse at least 20 percent better than N_2H_4 , offering greater packing efficiency for volume-constrained spacecraft.

A NASA-sponsored technology program at Primex Aerospace Company addressed the propellant development and thruster development of HAN-based monopropellants. This technology work involved laboratory-thruster testing of a range of amines, acids, and alcohols as fuel components in the HAN formulation; material compatibility testing with common aerospace materials; thermal stabilization; a strand-burning investigation; reactor development, including the screening of catalysts, injectors, and bed configurations; and life testing of a 4.5-N thruster.



1-lbf, HAN-glycine monopropellant thruster firing.

Testing was conducted with a formulation (60 wt % HAN, 26 wt % glycine, and 14 wt % water) compatible with off-the-shelf catalysts. The catalyst bed was preheated to 315 °C. Two series of steady-state tests were conducted, accumulating a total of 8000 sec of hot-fire life with 21 cold starts over a full range of feed pressures (2965 to 930 kPa). At the end of 8000 sec, the pressure had degraded approximately 7.5 percent from the original chamber pressure. Pulse mode testing was also conducted, with on times ranging from 0.100 to 300 sec, for duty cycles ranging from 0.5 to 100 percent.

The next-generation formulations will provide higher specific impulse values (>240 sec), which will reduce propellant system mass fractions by up to 25 percent, while still maintaining the nontoxic and thermal benefits. Candidate formulations have already been tested in a laboratory reactor and will be further developed in 2000. Since HAN-based formulations generally have higher molecular weights than N₂H₄, higher combustion temperatures are required to achieve N₂H₄-like performance. This will require the development of high-temperature catalyst materials or noncatalytic decomposition methods.

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